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Effect of different potassium levels on mungbean under custard apple based agri-horti system

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The experiment was conducted to study the effect of different potassium levels on mungbean under custard apple based agri-horti system at Agricultural Research Farm of Rajiv Gandhi South Campus, Barkachha, Mirzapur. The experiment was conducted in a complete randomized block design with seven treatments which were replicated thrice. These treatments were different doses of potassium, that is, 0 kg/ha (T_1), 20 kg/ha (T_2), 40 kg/ha (T_3), 60 kg/ha (T_4), 80 kg/ha (T_5), 100 kg/ha (T_6) and 120 kg/ha (T7). Potassium application is directly related to growth, plant biomass and yield in crops. Results showed that application of different potassium levels gave varying yield. Lowest yield (700 kg/ha) was obtained with the application of 0 kg/ha and highest yield (1096 kg/ha) was obtained with the application of 120 kg/ha potassium. It is concluded that the application of 80 kg/ha potassium gave highest Benefit/Cost ratio of mungbean and looks more remunerative in *Vindhyan* region.

Key word: Potassium, mungbean, custard apple, agri-horti system, growth, yield.

INTRODUCTION

Agri-horti system is an improved cropping system in which maximum utilization of natural resources markedly increases the return per unit area per unit time (Singh, 1987). Farmers realize the problem of no economic returns in the initial stage of fruit tree orchards till the tree starts bearing fruits. There is ample scope to utilize the introduction of the fruit tree during the initial 5 to 6 years by growing arable crops (Gill and Bisaria, 1995). Further, studies at Jhansi also revealed that interspaces of custard apple orchards can be exploited by intercropping grain and fodder crops during initial stage of establishment of fruit trees (Gill and Gangwar, 1992).

Mungbean is one of the most important pulse crops for protein supplement in subtropical zones of the world. It is widely grown in Indian subcontinent as a short duration catch crop between two principal crops (Afzal et al., 2008). It is becoming an important crop, as it is the best alternative to meet the food needs of the large population of developing countries due to its nutritional superiority and nitrogen fixing characters (Raza et al., 2012). Indian pulse production has been stuck in between 14 and 15 mt since mid-nineties, resulting in poor consumption (33 g/capita/day) during 2010 (Ali and Gupta, 2012). Mungbean can play the major role in national economy of India due to their wider adaptability, easy digestibility, better palatability and higher market price (Patil et al., 2003; Ramakrishna et al., 2000, Miah et al., 2009; Reddy, 2009). Potential yield of mungbean can be achieved through optimum use of inputs and agronomic practices. It is drought tolerant that can withstand adverse environmental conditions and hence successfully be grown in rain fed areas (Anjum et al., 2006).

Fertilizer is one of the most important factors that affect crop production. Fertilizer recommendation for soils and

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crops is a dynamic process (Rafiqul Hoque et al., 2004; Singh and Kumar, 2009; Singh et al., 2013) and the management of fertilizers is one of the important factors that greatly affect the growth, development and yield of mungbean (Asaduzzaman et al., 2008). Potassium application under drought moderates the adverse effects of water shortage on plant growth (Sangakkara et al., 2001; Singh and Kumar, 2009).

Potassium is the third macronutrient required for plant growth, after nitrogen and phosphorus (Abbas et al., 2011) and also plays a vital role as macronutrient in plant growth and sustainable crop production (Baligar et al., 2001). Its adequate supply during growth period improves the water relations of plant and photosynthesis (Garg et al., 2005), maintains turgor pressure of cell which is necessary for cell expansion, helps in osmotic-regulation of plant cell, assists in opening and closing of stomata (Yang et al., 2004), activates more than 60 enzymes (Bukhsh et al., 2011), synthesizes the protein, creates resistance against the pest attack and diseases (Arif et al., 2008) and enhances the mungbean yield (Ali et al., 2010).

Water deficit is frequently the primary limiting factor for crop production under arid and semi-arid conditions (Hussain et al., 2004). Potassium is essential in maintenance of osmotic potential and water uptake and had a positive impact on stomatal closure which increases tolerance to water stress (Epstein, 1972) and enhances water use efficiency (Nguyen et al., 2002). Potassium helps plant to adjust low water potential under drought stress (Bukhsh et al., 2012). Hence, under drought conditions, the accumulation of potassium increases in plant tissues that improves uptake of water from soil to plants. In general, potassium is accumulated in plants due to decrease in soil water potential. Consequently the water potential in the plant root further lowers and uptake of water continues. In drought, potassium maintains the turgor of the plant cell and regulates stomatal functions (Waraich et al., 2011). Potassium application improved the water content in the broad bean leaves and the plants showed more tolerance to drought stress (Thalooth et al., 1990).

The present study was therefore taken to investigate the effect of different levels of potassium on growth and yield performance of mungbean under custard apple based agri-horti system in rainfed conditions of *Vindhyan* region. Such study will be useful in order to create awareness among the farming community about the judicious use of fertilizer to get maximum production.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at the Agronomy Farm of Rajiv Gandhi South Campus, Barkachha (BHU), Mirzapur which is situated in *Vindhyan* region of district Mirzapur (25° 10' latitude, 82º 37' longitude and altitude of 147 masl) occupying over an area of more than 1000 ha where variety of crops like agricultural, horticultural, medicinal and aromatic plants are grown. *Vindhyan* soil comes under rainfed and invariably poor fertility status. This region comes under agro-climatic zone III A (semi-arid eastern plain zone). The climate of Barkachha is typically semi-arid, characterized by extremes of temperature both in summer and winter with low rainfall and moderate humidity. Maximum temperature in summer is as high as 39.8°C and minimum temperature in winter falls below 9ºC. The annual rainfall of locality was 209 mm in 2010, of which nearly 90% is contributed by South West monsoon between July and September. The total rainfall during the crop duration was 104.2 mm; maximum and minimum temperature fluctuated between 32.9 and 21.3°C, and relative humidity between 86.5 and 55.9%.

Soil analysis

The soil of the experimental field was sandy loam in texture with low drainage. It was acidic in reaction, poor in nitrogen as well as phosphorus and potash.

Experimental design and treatment

The experiment was conducted in Randomized Block Design with 7 (seven) treatments which were replicated thrice. These treatments were different doses of potassium, that is, 0 kg/ha (T_1), 20 kg/ha (T_2), 40 kg/ha (T_3), 60 kg/ha (T_4), 80 kg/ha (T_5), 100 kg/ha (T_6) and 120 kg/ha (T_7). The fertilizer application was done with fixed doses of nitrogen at 20 kg/ha and phosphorus at 40 kg/ha. Potassium application was done according to the treatments. All the nutrients were applied as basal and the sources of N, P and K were urea, DAP and MOP, respectively. The custard apple variety "Mammoth" was planted at 5 m × 5 m distance. Mungbean variety "HUM-12" was sown as an intercrop. The seeds were sown manually in the furrow opened by *kudal* at a row distance of 30 cm as per treatment. Seed rate 20 kg/ha was used for proper maintenance of plant population. A plant spacing of 10 cm within the row was maintained by thinning done about 10 days after sowing. First weeding was done manually by *khurpi* at 20 days and second weeding 30 days after sowing to control weeds. To protect the crop, mainly from leaf caterpillar, 250 ml/ha *Kranti* (Carpet hydrochloride 50% SP) was sprayed at 25 days after sowing. The biometric observations on growth attributes were recorded at an interval of 15 days, that is, 15^{th}, 30^{th} and 45^{th} days after sowing and at maturity. Growth attributes that is, plant height, number of trifoliate leaf per plant, number of branch per plant, number of root nodule per plant, dry matter accumulation per plant and yield attributes i.e, pod length, pod weight, number of pod per plant, number of seed per pod, test weight, seed yield and harvest index were measured. For protein content, seed sample from each plot was taken randomly ground and subjected to chemical analysis by Kjeldahl's method (Jackson, 1962). Available nitrogen percentage was determined through standard wet digestion method. Nitrogen percentage was converted to protein content by multiplying with constant factor (6.25) (Hiller et al., 1948).

RESULTS AND DISCUSSION

Plant height (cm)

Potash levels affected the plant height significantly (Table 1). Maximum plant height (52.5 cm) was obtained when potash was applied at 120 kg/ha which was statistically at

Table 1. Growth response of mungbean to different potassium levels under custard apple based agri-horti system.

Potassium (kg/ha)	Plant height (cm)	Number of branch per plant	Number of nodule per plant	Dry matter accumulation per plant (g)
0	46.0	3.5	20.0	9.63
20	48.0	3.8	24.0	10.86
40	49.5	4.0	26.0	12.53
60	50.5	4.3	27.5	13.44
80	51.5	4.5	28.3	14.06
100	52.3	4.5	28.8	14.48
120	52.5	4.5	29.5	14.77
S. E.	1.08	0.12	0.79	0.24
CD at 5%	3.34	0.37	2.46	0.75

par to all treatments except 0 and 20 kg potash per hectare. Minimum plant height (46 cm) was obtained in plots where no potash was applied, and no significant with 20 kg/ha might be due to high root/shoot ratio which is associated with potassium uptake (Yang et al., 2004). These results are in line with Hussain (1994) and Ali et al. (1996) who observed significantly higher plant height in mungbean crop when fertilized NPK at the rate of 60-100-100 kg/ha. Significant increase in plant height with potash application can be attributed to the fact that potash enhances plant vigour and strengthens the stalk (Das, 1999). These results are also in conformity with Asgar et al. (2007) in chickpea.

Number of branch per plant

Maximum number of branch per plant (4.5) was recorded in 120 kg potash per hectare though the differences were not significant with 100, 80 and 60 kg/ha, against minimum (3.5) in control which was found at par only with 20 kg/ha potassium application (Table 1). Potassium application increased the availability of nitrogen and phosphorus (Sahai, 2004) which resulted in better plant growth and more number of branches per plant.

Number of nodule per plant

Nodule formation was maximum with 120 kg being at par with 100, 80 and 60 kg K_2O per hectare but significantly different with rest of the doses. Minimum number of nodule per plant obtained with 0 kg K_2O per hectare which was significantly inferior to all the treatments. These findings were also supported by Kurdali et al. (2002) in chick pea.

Total dry matter accumulation per plant

Potassium level of 0 kg/ha recorded significantly lowest total dry matter accumulation than remaining doses while 120 kg/ha though at par with 100 and 80 kg K_2O per hectare recorded the highest total dry matter accumulation over rest of the potassium levels (Khan et al., 2001).

Seed weight per plant

Seed weight per plant was markedly affected by the potassium levels to produce the significant result (Table 2). Potassium dose of 0 kg/ha being at par with 20 kg/ha produced significantly lowest seed weight per plant than all other doses. Highest seed weight per plant was observed at 120 kg K_2O per hectare yet the differences were remained on par with 100 and 80 kg/ha. This can be attributed to higher number of pod per plant and number of seeds per pod. Similar results obtained by Asgar et al. (1994) in mungbean.

Number of pod per plant

Maximum number of pod per plant (13.01) was obtained when potash applied at 120 kg/ha though the differences were remained at par with 100 and 80 kg/ha (Table 2). Minimum number of pod per plant (9.02) was obtained where no potash was applied. Similar findings were recorded by Ali et al. (1996) who studied the effect of different potassium levels and reported that the number of pod per plant was influenced significantly by potassium application. The minimum number of pods where no potash was applied might have been due to less availability of N and P and stunted growth. The results are almost same as reported by Samiullah and Khan (2003).

Number of seed per pod

Maximum number of seed per pod (9.02) recorded with

Table 2. Yield attributes response of mungbean to different potassium levels under custard apple based agri-horti system.

Potassium (kg/ha)	Seed weight per plant (g)	Number of pod per plant	Number of seed per pod	Test weight (g)	Seed yield (kg/ha)
0	2.10	9.02	7.55	35.60	700
20	2.33	9.79	7.78	36.16	776
40	2.79	11.34	8.31	37.30	931
60	2.99	12.16	8.45	37.87	1000
80	3.15	12.56	8.60	38.14	1050
100	3.23	12.76	8.67	38.38	1078
120	3.27	13.01	8.72	38.50	1096
S. E.	0.08	0.21	0.15	0.86	25
CD at 5%	0.25	0.64	0.46	NS	78

120 kg/ha K_2O though the differences were only significant with 0 and 20 kg/ha which were remained on par and found lowest (8.72) (Table 2). Potassium application not only enhanced the availability of other nutrient but also increased the photosynthetic activity (Samiullah and Khan, 2003) and transportation of photosynthates from source to sink might be the main reason for increase in number of seed per pod Ali et al. (1996). Significant increase in number of seeds per pod due to application of potash was also reported by Asgar et al. (2007).

Test weight

Data revealed that test weight of mungbean with each increment of potassium could not touch the level of significance. Similar result was also found by Oad et al. (2003).

Seed yield

Seed yield affected significantly by potassium levels up to the 80 kg/ha and beyond that level the differences were remained on par (Table 2). Minimum seed yield (700 kg/ha) was observed in plot where no potash fertilizer was applied even though that was not significantly different with 20 kg/ha. These results are in agreement with those of Ali et al. (1996) and Hussain (1994). The highest seed yield (1096 kg/ha) in case of 120 kg K_2O per hectare can be attributed to more number of pod per plant and number of seed per pod. Similar result was concluded by Samiullah and Khan (2003).

Nitrogen, phosphorus and potassium contents of seed

Nitrogen, phosphorus and potassium contents increased with the enhanced doses of potassium. Potassium dose of 120 kg/ha being at par with 100 and 80 kg/ha revealed significantly higher N content in seed than rest of the levels. Potassium exerted non significant response for P content in seed from 120 kg to 40 kg/ha while rest of the doses differed significantly when compared with highest dose. Potassium dose of 120 kg/ha being at par with 100 and 80 kg/ha realized significant difference for K content in seed over rest of the levels. Maximum N, P, and K contents obtained with the 120 kg K_2O per hectare and minimum with the 0 kg K_2O per hectare (Table 3). This finding was in full agreement with Singh et al. (2002).

Protein content (%)

Protein content of mungbean seed was affected significantly by different potassium levels. As for different treatments are concerned, the application of 120 Kg K_2O per hectare resulted in maximum seed protein content (25.63%) and minimum in control (23.30%) (Table 3). It was observed significantly different over the 0, 20 and 40 kg potash per hectare. As potash has synergistic effect on nitrogen uptake, facilitates protein synthesis and activates different enzymes (Das, 1999), therefore, protein content increased significantly with each increase in potassium level. Similar findings were also reported by Mali et al. (2000). Chanda et al. (2002) concluded that the application of higher level of potash also increased the protein content of mungbean. This result is in close similarity with Srinivasarao et al. (2003) and Asgar et al. (2006).

Growth parameters of custard apple

Statistically non significant differences observed in the mentioned growth parameters of custard apple might be due to shorter growth phase of mungbean which could not realized the noticeable changes in the limited

Table 3. Nutrient and protein content of mungbean to different potassium levels under custard apple based agri-horti system.

Potassium (kg/ha)	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Protein (%)
0	3.702	0.350	0.688	23.30
20	3.707	0.353	0.708	23.80
40	3.716	0.356	0.743	24.60
60	3.722	0.357	0.760	25.22
80	3.726	0.359	0.775	25.36
100	3.729	0.360	0.787	25.56
120	3.730	0.361	0.797	25.63
S. E.	0.002	0.002	0.011	0.30
CD at 5%	0.007	0.006	0.032	0.92

Table 4. Growth parameters of custard apple at various crop growth stages in custard apple based agri-horti system.

Potassium (kg/ha)	Tree height (m)		Collar diameter (cm)		Canopy spread (cm)	
	At crop sowing	At crop harvesting	At crop sowing	At crop harvesting	At crop sowing	At crop harvesting
0	2.59	2.67	5.21	5.3	1.56	2.1
20	1.87	1.96	5.73	6.04	2.07	2.65
40	2.15	2.25	4.77	5.09	2.3	2.9
60	1.84	1.94	4.83	5.2	2.27	2.89
80	2.36	2.46	4.35	4.77	1.79	2.43
100	2.31	2.41	4.67	5.2	1.83	2.47
120	1.85	1.96	3.85	4.45	2.09	2.88
SE	0.2	0.2	0.85	0.83	0.23	0.25
CD at 5%	NS	NS	NS	NS	NS	NS

Table 5. Economics of mungbean as influenced by potassium levels under custard apple based agri-horti system.

Potassium (kg/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	Benefit/Cost
0	10087	45446	35359	3.50
20	10287	48326	38039	3.69
40	10487	54204	43717	4.16
60	10687	56809	46122	4.31
80	10887	58681	47794	4.39
100	11087	59634	48547	4.37
120	11287	60411	49124	4.35

observation period (Table 4).

Economics

It is evident from the data that maximum and minimum gross return recorded Rs. 60411 and Rs. 45446 ha^{-1} from potassium level of 120 kg and 0 kg K_2O per hectare respectively. Data indicates that the total cost of cultivation also followed the same trend. The highest net return (Rs.49124) was recorded from the potassium dose of 120 kg/ha, while minimum net return obtained with 0 kg/ha (Rs 35359). Similar results obtained by Asgar et al. (2007) in chickpea. The maximum benefit: cost ratio (4.39) was recorded with 80 kg K_2O per hectare and minimum (3.50) was obtained with 0 kg K_2O ha^{-1} (Table 5

Conclusion

Significant response observed in growth and yield up to potassium application level of 80 kg/ha and benefit/cost ratio was also found maximum, so it is recommended that farmers should use 80 kg potassium per hectare in mungbean under custard apple based agri-horti system.

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